Comparison of resting heart rate measured using a cardiac monitor and an oscilometric device in adolescents: analysis of sensitivity and specificity

Comparação da frequência cardíaca em repouso medida usando um monitor cardíaco e um aparelho oscilométrico em adolescentes: análise de sensibilidade e especificidade

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ABSTRACT

Study design: Experimental study

Objectives: To assess the consistency and efficiency of an oscillometric device for measuring resting heart rate in adolescents.

Methods: Data from adolescents of both sexes aged between 10 and 15 years were analyzed. Weight was measured using a digital scale and height, a stadiometer. Body mass index was calculated by dividing body weight by the height squared. The resting heart rate was measured with a heart rate monitor and an oscillometric device for measuring blood pressure. The mean and standard deviation were used to describe the characteristics of the sample. Pearson's correlation was used to examine the relationship between the two devices. Reproducibility was assessed by the intraclass correlation coefficient and efficiency by the receiver operating characteristic curve.

Results: Moderate/high correlations were found (r=0.80) between the heart rate monitor and oscillometric device. The intraclass correlation coefficient showed values of 0.88 (0.66–0.96) for girls and 0.90 (0.82–0.95) for boys. The sensitivity was 70.0 (34.8–93.3) and 80.4 (28.4– 99.5) and the specificity 86.6 (69.3–96.2) and 90.0 (55.5–99.7) for boys and girls respectively.

Conclusion: The oscillometric device showed good reproducibility and moderate sensitivity and specificity for measuring resting heart rate in adolescents.

Keywords: Heart Rate. Blood Pressure Monitors. Adolescent.

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RESUMO

Desenho do estudo: Estudo experimental

Objetivos: avaliar a consistência e eficiência de um aparelho oscilométrico para medir frequência cardíaca em repouso em adolescentes.

Métodos: Os dados de adolescentes de ambos os sexos, com idade entre 10 e 15 anos foram analisados. O peso foi medido utilizando uma balança digital e altura, um estadiômetro. Índice de massa corporal foi calculado dividindo-se o peso corporal pela altura ao quadrado. A frequência cardíaca de repouso foi medida com um monitor de frequência cardíaca e um aparelho oscilométrico para medir a pressão arterial. A média e o desvio padrão foram utilizados para descrever as características da amostra. A correlação de Pearson foi usada para examinar a relação entre os dois dispositivos. A reprodutibilidade foi avaliada pelo coeficiente de correlação intraclasse e eficiência pela curva ROC.

Resultados: média / alta correlações foram encontrados (r = 0,80) entre o monitor de frequência cardíaca e aparelho oscilométrico. O coeficiente de correlação intraclasse apresentaram valores de 0,88 (0,66-0,96) para as meninas e 0,90 (0,82-0,95) para os meninos. A sensibilidade foi de 70,0 (34,8-93,3) e 80,4 (28.4- 99.5) e a especificidade de 86,6 (69,3-96,2) e 90,0 (55,5-99,7) para meninos e meninas, respectivamente.

Conclusão: O aparelho oscilométrico mostrou boa reprodutibilidade e moderada sensibilidade e especificidade para medir a frequência cardíaca de repouso em adolescentes.

Palavras-chave: Frequência Cardíaca. Monitores de Pressão Arterial. Adolescente.

Introduction

There is currently a high prevalence of risk factors for cardiovascular disease in the adult population,[1,2,3] which is considered a worrying factor, as this type of disease is a major cause of morbidity and mortality.[4] Such risk factors are also observed with high frequency in pediatric populations[5,6] and strategies to avoid them are recommended from early ages, since risk factors developed in childhood and adolescence can be carried though to adulthood.[7,8]

Among the various cardiovascular risk factors, elevated resting heart rate is considered a risk factor which is independent of other factors such as obesity, hypertension, a sedentary lifestyle, and insufficient physical activity. Fernandes et al.,[9] in a study involving 971 adolescents aged 11 to 17 years, found that high resting heart rate was associated with dyslipidemia and elevated levels of glucose in this population. Epidemiological studies also indicate that elevated heart rate at rest is related to high blood pressure in children and adolescents.[10,11]

Thus, evaluating resting heart rate at early ages seems to be an essential preventive action to prevent possible cardiovascular risk factors being initiated in childhood or adolescence. Oscillometric devices which measure systolic and diastolic blood pressure together with the resting heart rate may be an interesting alternative technique. These devices are portable, lightweight and usually inexpensive.

However a search in the literature identified only articles that verified the performance of these automated devices compared to other accurate assessment methods solely with regard to arterial pressure.[12-15] Verifying whether such devices present the same efficiency for the measurement of resting heart rate could contribute to the organization of health promotion activities. Thus, the aim of this study was to determine whether an oscillometric device for measuring blood pressure would have good reproducibility and sensitivity to analyze resting heart rate in adolescents.

Methods

The study sample was composed of adolescents of both sexes, aged between 10-15 years living in the city of Presidente Prudente-SP, Brazil, and formed part of a physical activity intervention project offered by the proponent institution of this study in partnership with a nonprofit organization to which the young people were linked. For inclusion in the study the adolescents were required to fulfill the following criteria: i) not be taking medicines to control heart rate; ii) not have practiced strenuous ex-

ercise for a minimum of 24 hours prior to the assessment; iii) not have consumed caffeinated beverages for 24 hours prior to the evaluation; iv) not be pregnant; v) present the term of consent form signed by a parent or guardian authorizing participation in the study.

The sample size calculation assumed a value of r= 0.50, an alpha error of 5% and power of 80%, giving a minimum sample size of 30 adolescents. Predicting a 20% loss due to refusals to participate in heart rate measurements or absences on the day of assessment, the minimum size required was 36 teenagers. Altogether 55 adolescents participated in the study.

Anthropometry

To compose the sample characterization of the present study, body weight was measured using a digital scale accurate to 0.1 kg. Height was measured using a fixed stadiometer accurate to 0.1 cm and a maximum length of two meters. From these anthropometric values the Body Mass Index was calculated by dividing body mass by the height squared.

Resting heart rate

Before the heart rate measurement, the adolescents were seated in a chair with their legs uncrossed, feet flat on the floor, leaning back and relaxed, for a period of 15 minutes during which they were asked to remain silent, as recommended by the VI Hypertension. Guidelines.[16.]

The heart rates were measured using a heart rate monitor (Polar Electro, Model FT-1, T-31 Coded Transmitter-Oowncod, Kempele, Finland). This device is light, weighing 230 grams, and has a transmitter that transmits the heartbeat to a watch on one of the user's arms. The heart rate transmitter was placed at the xiphoid process on the adolescents and the values of the heartbeat of these young people while at rest were obtained.

The second measurement was performed, using an oscillometric device for measuring blood pressure (Omron Corporation, Model HEM 742, Kyoto, Kansai, Japan) with a cuff size appropriate to the arm circumference of each participant. This device is lightweight, portable and consists of an electronic digital device and blood pressure measurement arm with automatic inflation and deflation of air, which also provides heart rate values.

The blood pressure monitor (Omron Corporation, Model HEM 742, Kyoto, Kansai, Japan) performs the measurement of heart rate through sensors and algorithms contained in the device. The measurement was made on the right arm following procedures in the literature[17].The two measurements were performed at the same time. When the oscillometric device reported the value of heart rate, these were recorded, along with the value of the cardiac frequency obtained in heart rate monitor. For the analysis of sensitivity and specificity, heart rate was categorized into quartiles, with the adolescents in the highest quartile considered as having a high heart rate.

Statistics analyses

Data normality was verified using the Kolmogorov-Smirnov test. After verifying that the values fell within the Gaussian distribution model, the characterization variables of the sample were expressed as mean and standard deviation. To analyze the relationship between the values of heart rate assessed using the heart rate monitor and the oscillometric device, Pearson's correlation was used. The t test for paired samples was used to compare the measurements of heart rate recorded using the heart rate monitor and the oscillometric device. The reproducibility between the two devices was observed using the intraclass correlation coefficient and the Bland-Altman plot analyzed the correlation of heart rate values between the two devices. The sensitivity and specificity of the oscillometric device to measure heart rate were determined by the receiver operating characteristic curve. The statistical significance adopted in this study was 5%.

Results

Table 1 presents the characteristics of the sample as a whole (boys and girls together). When the analysis was stratified by sex the only differences were age, girls (11.05 [SD = 1.35]) and boys (11.98 [SD = 1.40], p = 0.017) and stature, girls (155.66 [SD = 11.90]) taller than boys (149.18 [SD = 11.90]); p = 0.029.

Table 1. Characteristics of the sample.

	Mean	SD	Minimum	Maximum
Age (years)	11.68	1.44	10.00	15.00
Weight (kg)	46.91	12.71	24.50	74.90
Height (cm)	153.60	11.04	126.80	178.60
BMI (kg/m^2)	19.62	3.96	13.25	31.62

SD= Standard deviation; BMI= Body mass index.

The overall correlation between the heart rate monitor and the oscillometric was considered moderate/high (r= 0.83; $p \leq 0.001$), remaining after stratification by sex, girls (r=0.79; $p \leq 0.001$) and boys (r=0.84; $p \leq 0.001$). Table 2 provides information comparing the overall averages and stratified by sex of the heart rate values measured using the heart rate monitor and the oscillometric device. No statistically significant differences between the values were identified. The reliability of the apparatus, demonstrated by the intraclass correlation coefficient presented moderate/high values.

To verify the correlation between the heart rate reported by the two devices the Bland-Altman plot statistical method was used. Regarding heart rate values, it was noted that of the 55 measurements, only 5.4% (n= 3) were outside the confidence interval of 95% (Figure 1).

Table 2. Mean values for the total sample and stratified by gender of heart rate according to the two instruments.

	HRM	OD	*P*	ICC (IC=95%)
Total	78.59	79.98	0.200	0.90 (0.83–0.94)
Boys	80.47	82.00	0.454	0.90 (0.82–0.95)
Girls	77.85	79.22	0.303	0.88 (0.66–0.96)

HRM=Heart rate monitor; OD= Oscillometric device; ICC= Intraclass correlation coefficient

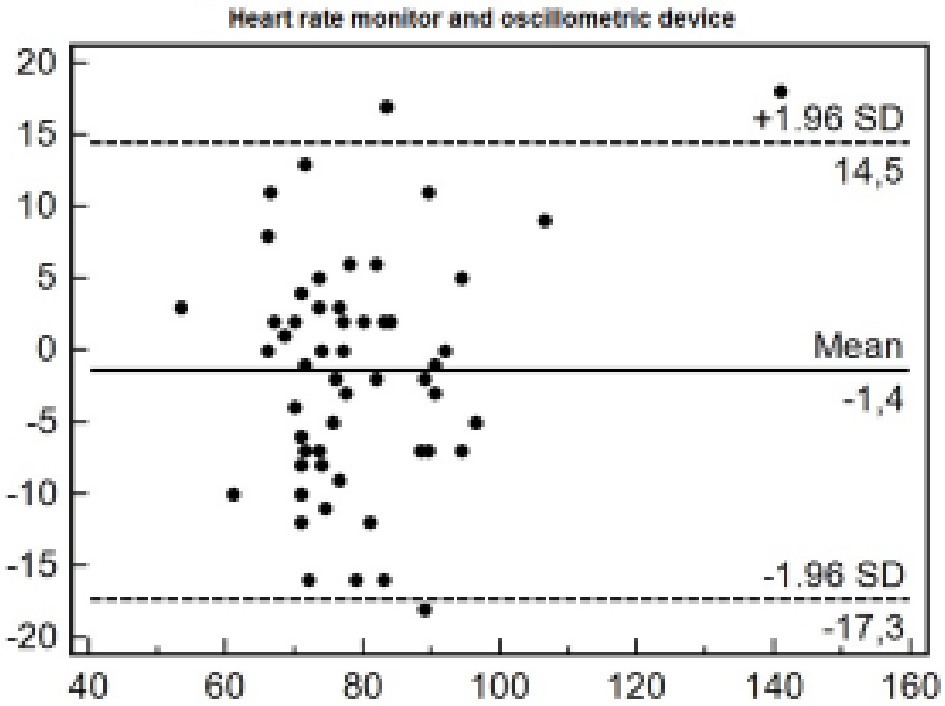

Figure 1. Bland-Altman Plot for average values of the difference between the heart rate monitor and the oscillometric device.

As cutoff points do not exist for elevated heart rate, the values were divided into quartiles, and the adolescents located in the highest quartile (Q4) were considered to have elevated heart rate. From this we calculated the sensitivity and specificity of the oscillometric device in predicting a possible elevated heart rate. The values of sensitivity found were moderate, whereas the specificity values were higher, close to 90% (Table 3).

Discussion

The aim of the present study was to determine, compared to more sophisticated methods (heart rate monitor), whether a blood pressure oscillometric device,(Omron Corporation, Model HEM 742, Kyoto, Kansai, Japan), which also measures heart rate values, has good reproducibility and sensitivity in the analysis of resting heart rate in adolescents. When comparing the mean values of heart rate from the two devices, there was no statistically significant difference although the oscillometric device overestimated the values of heart rate recorded by two heartbeats, which could be linked to the form of calculation each machine uses to discriminate heart rate.

In our study, good agreement was observed between the values measured by the intraclass correlation coefficient analysis. In the study of Mattioli et al.[18] an oscillometric device (Omron HEM-907, Netherlands) was used for measuring resting heart rate and according to the manufacturer's instruction manual there is an expected accuracy of around 95% between readings of this variable. The authors analyzed the intraclass correlation for 10 measures of resting heart rate, measured using the same apparatus and observed values of intraclass correlation coefficient of 0.97 (0.96 to 0.99) between these measures. Thus, there was no variation greater than 10% in the results in relation to the average resting heart rate and there was a high correlation between the measurements of heart rate, indicating good reliability of the device.

The correlation values between the heart rate monitor and the oscillometric device also demonstrated a good relationship (r= 0.80), considered moderate to high. The results show that these devices could be used in environments such as schools. Recent studies with the objective of verifying resting heart rate in adolescents and associated factors have used oscillometric devices to measure the heart rate.[9,10]

The expectation is that these devices may be used to assist in preventive measures related to risk factors for cardiovascular disease carried out in schools. There are currently no actions for effective promotion being carried out in such environments with regard to resting heart rate, however, recent studies indicate that this is a risk factor which must be evaluated from the earliest ages.[9,11,19]

These types of devices have been widely used for assessment of blood pressure in epidemiological studies in pediatric populations.[21-24] Such devices are usually subjected to validation protocols by international bodies such as the British Hypertension. Society[25] and Association for the Advancement of Medical Instrumentation,[26] however there is no specific protocol for heart rate values.

In this regard, to verify the efficiency of the apparatus the receiver operating characteristic curve was used. Moderate values were found for the outcomes sensitivity and specificity. It is noteworthy that in this study the values of elevated heart rate

Table 3. Sensitivity and specificity in the indication of the values of heart rate.

	Oscillometric Device		
	Sensitivity	Specificity	AUC (95%IC)
Total	73.3 (44.9 – 92.2)	87.50 (73.2 – 95.8)	79.2 (64.2 – 94.0)
Boys	70.0 (34.8 – 93.3)	86.6 (69.3 – 96.2)	78.3 (62.5 – 89.8)
Girls	80.4 (28.4 – 99.5)	90.0 (55.5 – 99.7)	85.0 (57.6 – 97.8)

IC= Confidence interval; AUC= Area under the curve.

were assessed according to quartiles and the highest quartile (Q4) was considered 'at risk' as there is no scientific literature on specific cutoff points for detecting high heart rate frequency in children and adolescents.

The results of this study demonstrate that the device used in this study can be used in school environments as a form of screening to identify high values of resting heart rate in young people, enabling their referral to medical or basic health care units for preventive care to be implemented and heart rate monitored more specifically.

Conclusion

The oscillometric device evaluated in this study had moderate to high values with respect to agreement and moderate values for sensitivity and specificity to analyze resting heart rate, indicating that this type of device can be used in the school environment as a means of screening to analyze resting heart rate in the young population.

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Conflicts of Interest: None

Ethical Standards
All procedures used in this study were approved by the Committee for Ethics in Research of the proponent institution of the study (Protocol. No. 21600613.4.0000.5402).Our study followed the Declaration of Helsinki.

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